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BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPER IN THIS NUMBER

“Wood and Concrete Piling. An Informal Discussion.”

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Contributors are hereby notified that proof will not be submitted to them for examination unless requested before the 10th of the month preceding the month of publication.

MINUTES OF MEETINGS.

BOSTON, November 17, 1920. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order at 8 o'clock by the President, Frank A. Barbour.

There were 195 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government the election to membership of the following candidates in the grades named: As members — Messrs. Frank J. McCann and C. Hale Sutherland; and as a junior — Mr. John Lucas.

The Secretary also reported for the Board of Government the result of the questionnaire on the Report of the Committee on Compensation of Engineers, sent out by vote of the Society at its September meeting, as follows:

Total number replies received.....	325
Number not signed.....	14
Total number counted.....	311

In answer to the first question:

"Do you agree with the recommendations of the Committee on Compensation of Engineers that the Society should endorse the schedule of salaries approved by Engineering Council?"

Number answering "Yes" 273
 Number answering "No" 23
 Blanks 15

The Schedule of Engineering Council is as follows:

Grade.	Total Years' Experience Required to Qualify		Salary Range.	
	With Professional Degree.	Without Professional Degree.	Minimum.	Maximum.
8—Junior.....		0	\$1 080	\$1 560
7—Aid.....		2	1 680	2 400
6—Senior Aid.....		5	2 520	3 240
5—Junior Assistant Engineer	0	4	1 620	2 580
4—Assistant Engineer.....	2	6	2 700	4 140
3—Senior Assistant Engineer	5	9	4 320	5 760
2—Engineer.....	8	12	5 940	No limit
2—Chief Engineer.....	12	16	8 100	No limit

In answer to the second question:

"Do you agree with the report of the Committee on Compensation of Engineers that the preceding schedule should apply equally to public and private service?"

Number answering "Yes" 264
 Number answering "No" 38
 Blanks 9

The President stated that the December meeting would be a joint meeting in which the Boston sections of the American Society of Mechanical Engineers and of the American Institute of Electrical Engineers would participate, and it would be a convenience to these sections if the meeting were held on Friday, December 17, instead of December 15, the regular date for holding our next meeting.

On motion of Mr. Weston, it was voted to advance the date of the next meeting from December 15 to December 17.

The President then called on Past President John R. Freeman, who gave a most interesting talk on "Some Engineering Problems of China and the Far East."

The talk was illustrated by a large number of lantern slides, some of them beautifully colored.

A short discussion followed Mr. Freeman's talk, in which Past President Desmond FitzGerald spoke of some of his observations in China.

At 10.15 Vice-President Weston, who was in the chair, declared the meeting adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., October 6, 1920. — A meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening in the Society Rooms, Tremont Temple. The meeting was called to order at 8.00 P.M., by Chairman Edward Wright.

The records of the annual meeting were read and approved as printed in the JOURNAL.

The chairman stated that he had appointed Messrs. Frank A. Marston and H. E. Holmes on the Committee on Inverted Siphons.

The chairman then introduced Mr. R. H. Eagles, chemical engineer for the Dorr Company, who spoke on "The Treatment of Sewage and Trade Wastes by Mechanical Methods, with Special Reference to the Dorr Systems" and "The Dorr-Peck Modification of the Activated Sludge Process of Sewage Treatment."

Mr. Eagles described, in detail, the Dorr Systems and the method of operation, and spoke particularly on the experimental work at Mt. Vernon, N. Y.

The subject was discussed by H. P. Eddy, R. S. Weston, F. A. Barbour, Leonard Metcalf, A. L. Fales and others.

On motion of Mr. Marston, a rising vote of thanks was given to Mr. Eagles for his kindness in speaking to the section.

The talk was illustrated by means of the reflectoscope.

A miniature Dorrco screen, Dorr sewage clarifier and Dorr-

Peck aerator, operated by an electric motor, were exhibited in the main library. This apparatus was furnished by the Dorr Company.

The meeting adjourned at 9.40.

Members present, 41.

JOHN P. WENTWORTH, *Clerk.*

BOSTON, MASS., November 3, 1920. — A regular meeting of the Sanitary Section was called to order at 8.00 P.M. this evening, by Chairman Edward Wright, in Chipman Hall, Tremont Temple.

There being no objection, the minutes of the previous meeting were filed without being read. The chairman announced a hearing upon a proposed revision of plumbing regulations, to be held at the State House at 4 P.M., November 9, 1920, in which it has been urged that engineers interest themselves. It was also announced that Mr. T. Chalkley Hatton, chief engineer, Milwaukee Sewerage Commission, would address a special meeting of the Section, Wednesday evening, November 10, upon the status of the activated sludge plans of Milwaukee.

Prof. G. C. Whipple was then introduced and gave an account of his recent experiences in Europe as director of the Department of Sanitation of the League of Red Cross Societies. He described the development of the League, outlined his impressions of Geneva, its headquarters, which is also the "capital" of the League of Nations, and discussed conditions, both political and sanitary, as he found them in Roumania. His audience of 62 included many ladies who came as guests of members.

The meeting adjourned at 9.20.

A. L. SHAW, *Acting Clerk.*

BOSTON, October, 6 1920. — A meeting of the Designers Section of the Boston Society of Civil Engineers was called to order at 6.20 P.M. by Chairman R. W. Horne.

After the minutes of the previous meeting were read and accepted, it was moved, seconded and carried, that the Section

concur in the modification of the By-Laws required by the Board of Government. The By-Laws therefore stand approved and accepted as published in the June, 1920, JOURNAL.

Mr. Charles R. Gow then reviewed the history of " Borings " from the earliest method of sounding with rods to the modern use of wash and core-borings apparatus. His talk was followed with great interest by the 27 members and guests present, and covered the subject in a very complete manner.

Mr. John T. Scully followed, with an account of some of his experiences in investigating foundations by means of borings, including some novel methods employed in the earlier days of the art.

General discussion followed, and the meeting was adjourned at 8.20.

ARTHUR L. SHAW, *Clerk.*

BOSTON, MASS., November 11, 1920. — A meeting of the Designers Section was called to order in the Society Library, with 27 present and Chairman Horne presiding.

After the minutes of the previous meeting were read and approved, the first speaker, Mr. John H. Hession, was introduced and outlined the history of waterproofing and described the various methods that have been employed. Mr. J. Francis Travers, Jr., then made a plea for greater coöperation between architects or engineers and the waterproofing contractor, urging the desirability of consulting the latter in the early stages of design and of giving him a free hand to get results in his own way on the job.

Vice-Chairman Rice emphasized the advantage of carefully proportioning the aggregates of a concrete, thus increasing the density and securing a measure of waterproofing without the introduction of outside agents. He also mentioned the growing use of fine ground cement as a means of securing greater density and reducing the inert content of the cement.

Mr. Edward S. Larned, who was to have spoken, was unable to be present, but sent a letter discussing points similar in general to those covered by Mr. Rice.

The meeting adjourned at 8.00 P.M., after further discussion by several members.

A. L. SHAW, *Clerk.*

APPLICATIONS FOR MEMBERSHIP.

[December 15, 1920.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

CHASE, WILLIAM HENRY, New Bedford, Mass. (Age 44, b. Taunton, Mass.) 1895-1902, chainman, rodman and transitman on municipal work, city of Bedford; 1902-3, inspector and draftsman on textile mill construction, with W. F. Henry, mill engineer; Fall River: 1903-5, transitman on railroad location, and assistant engineer on track and bridge construction, Lake Shore & Michigan Southern Ry Co.; 1905-6, inspector in station construction, and assistant engineer on track relocation and electrification for New York Central R.R., New York, N. Y.; 1906-9, assistant engineer and later superintendent of construction, with Snare & Triest Co., New York, on building of foundation and approach of the 184th St. highway bridge, New York City, and Long Island approach to Queensboro Bridge; 1909, superintendent of construction, Standard Construction Co., Chicago; and 1909 to date, assistant engineer, Engineering Department, City of New Bedford, Mass. Refers to A. B. Drake, H. E. Holmes, G. H. Nye, H. F. Sawtelle, C. L. Wade and W. F. Williams.

CLARK, THEODORE PARKER, Winchester, Mass. (Age 39, b. Cambridge, Mass.) Educated in the public schools of Cambridge; graduate of Rindge Technical School, 1901; and at Northeastern College, 1914-15, civil engineering course. From Dec., 1901, to April, 1904, engaged in mechanical and electrical work; May, 1904, to May, 1912, with Street Department of Cambridge as clerk and foreman in charge of all branches of municipal work; May, 1912, to April, 1913, superintendent and engineer of Street Dept., Needham, Mass.; April to July, 1913, instructor for Barrett Co., on use of tar for road work;

July, 1913, to June, 1915, Cambridge Street Dept., as supervisor of construction; June, 1915, to date, superintendent of Dept. of Highways, Winchester, Mass. Refers to A. W. Dean, L. M. Hastings, H. V. Macksey, C. R. Main, R. W. Pond and D. W. Pratt.

GARVIN, FRANCIS ARTHUR, Brighton, Mass. (Age 46, b. Brighton, Mass.) Educated in the Boston schools, and special engineering courses in correspondence schools and private tutoring. From May, 1896, to October, 1903, rodman and instrument man, Street Laying-Out Dept., Boston, Mass.; October, 1903, to date, draftsman and instrument man in charge of party for precise leveling and construction work on sewer service, City of Boston. Refers to T. F. Bowes, C. S. Drake, E. F. Murphy, J. E. L. Monaghan, E. H. Rogers and F. O. Whitney.

HARVEY, JAMES FRANCIS, Dorchester, Mass. (Age 23, b. South Boston, Mass.) Studied at Franklin Union for three years in heating and ventilating, practical science, mensuration shop arithmetic. With French & Hubbard two years, 1914-16, as draftsman; with Monks & Johnson six months as draftsman; six months with Hope Engineering Co., and from September, 1919, to date, draftsman with Lockwood, Greene & Co. Refers to W. W. Bigelow, M. J. O'Brien, E. P. Rankin, H. F. Sawtelle, H. C. Thomas and J. F. Wilber.

HINDS, JAMES, Winchester, Mass. (Age 50, b. Winchester, Mass.) Has been engaged in engineering for the Town of Winchester since 1895, and has been its town engineer since 1903. His work has been the municipal engineering work of the town, sewerage, storm-water drainage, street construction, etc. Refers to H. K. Barrows, A. W. Dean, C. T. Main and D. W. Pratt.

HOLBROOK, PARKER, Winchester, Mass. (Age 32, b. Malden, Mass.) High-school education. Has had twelve years' experience in surveying and municipal engineering. At present, assistant engineer with Town of Winchester. Refers to H. K. Barrows, C. H. Gannett, C. T. Main, D. W. Pratt, R. W. Pond and F. E. Sherry.

KEITH, SCOTT, Newton, Mass. (Age 22, b. Newton, Mass.) Graduate in civil engineering, Mass. Institute of Technology, 1918. Draftsman in Hull Dept. at Cramp Bros., Ship and Engine Bldg. Co., Philadelphia, Pa., Jan. to June, 1919; assistant civil engineering department, M. I. T., Aug., 1919, to June, 1920; at present on engineering staff of Metcalf & Eddy. Refers to H. K. Barrows, F. A. Marston, Leonard Metcalf, Dwight Porter, C. W. Sherman and C. M. Spofford.

KRIGGER, ANSELMO, Cambridge, Mass. (Age 28, b. New York City.) Graduate of Mass. Institute of Technology, degree of B.S., in civil engineering, in 1917. From Sept., 1917, to date, with Mass. Dept. of Public Works, Division of Highways, with the exception of four months in U. S. Army. Has been resident engineer on highway construction, and is at present assistant engineer with the Public Works Department. Refers to A. B. Appleton, A. P. Rice, R. A. Vesper and W. N. Wade.

LEARY, CHARLES ARTHUR, Swampscott, Mass. (Age 41, b. Waltham, Mass.) Three years at Mass. Institute of Technology, class of 1900. Engaged

in mining engineering, Spangler, Pa., 1901-6; with G. M. Bryne Co., general contractors, Boston, 1907-8; with Boston Elevated Railway on engineering surface lines, 1909-10; engineer, Public Works Dept., Peabody, Mass., 1911-12; engineer, Mass. Bonding & Insurance Co., Boston, 1918-19, and at present superintendent of the Charles R. Gow Co. Refers to C. R. Gow, R. W. Horne, G. L. Myrick and J. W. Rollins.

LELAND, FRANKLIN EDWARD, Newton, Mass. (Age 30, b. Ashfield, Mass.) Graduate, Sanderson Academy, Ashfield, 1907. In 1907 engaged in land surveying at Greenfield, Mass.; from 1907 to 1914 draftsman as follows: Greenfield Tap & Die Co., 1907-8; Chase Turbine Mfg. Co., Orange, Mass., 1908-9; Kilham & Hopkins, architects, Boston, 1910-11; Allen & Collens, architects, Boston, 1912-14; with Boston & Albany R.R., as estimator, valuation department, 1915; Stone & Webster, Inc., as designer, 1915-18; Fay, Spofford & Thorndike, as designer, 1918-19; with Aberthaw Construction Co., as designer, 1919; and at present resident engineer and designer with Fay, Spofford & Thorndike. Specialist in design of reinforced concrete. Refers to C. R. Berry, B. A. Bowman, L. F. Cutter, H. A. Gray, W. F. Pike and W. D. Trask.

MACLEAY, FRANCIS RODERICK, Barre, Vt. (Age 24, b. Barre, Vt.) Educated in schools of native town and in civil engineering courses of one year at Franklin Union, Boston, and three years at Northeastern College, Boston, also one year at Suffolk Law School, Boston. From July, 1915, to Aug., 1916, draftsman with C. W. McMillan & Sons, Barre, Vt.; Aug., 1916, to Nov., 1917, draftsman with Cook, Watkins & Co., Boston; Nov., 1917, to March, 1918, plant draftsman, Western Union Telegraph Co., Boston; May to Sept., 1918, party chief with F. F. Jonsberg Co., Boston; September, 1918, to Jan., 1919, superintendent for C. W. McMillan & Sons, Barre, Vt.; Jan. to March, 1919, on public service appraisal, F. F. Jonsberg Co.; March to Oct., 1919, draftsman and party chief, Massachusetts Department of Public Works, Highway Division, and at present head of the mathematical department, Goddard Seminary, Barre, Vt. Refers to A. W. Dean, F. F. Jonsberg, A. M. Lovis, C. H. Restall, A. P. Rice, W. N. Wade.

MARTIN, ALBERT GEORGE, Milton, Mass. (Age 23, b. Brookline, Mass.) Graduate of Milton High School, 1917, and of Wentworth Institute in 1920. Summer of 1919, plan clerk for Lockwood, Greene & Co., and in 1917, surveying for W. W. Churchill, Milton, Mass. At present draftsman with Lockwood, Greene & Co. Refers to W. W. Bigelow, M. J. O'Brien, E. P. Rankin, H. F. Sawtelle, H. C. Thomas and H. A. Varney.

NEWCOMB, GEORGE HOLLAND, Quincy, Mass. (Age 34, b. Newburyport, Mass.) Graduate of Quincy High School in 1903, and post-graduate in 1904. From July, 1904, to Feb., 1905, in charge of plans, hull drafting room, Fore River Shipbuilding Co.; May, 1905, to Feb., 1906, rodman with Whitman & Howard, Boston, and from May, 1906, to date, with E. W. Branch, Boston and Quincy, on general engineering and surveying, except from Aug., 1917, to April, 1919, with the 101st U. S. Engineers, Co. B. Refers to E. W. Branch, Perry Lawton, E. C. Sargent, F. E. Tupper, H. L. White and R. H. Whitney.

TRAVERS, JOSEPH FRANCIS, Jr., Cambridge, Mass. (Age 40, b. Boston, Mass.) Educated in the public schools of Boston, including Mechanic Arts High School. Ten years' experience as concrete engineer on waterproofing construction and design. Has carried through successfully the waterproofing of cellars, basements, tunnels, swimming pools, boiler-room tanks, sewers, dams, motor pits and various other works. Has been with the National Waterproofing Co. for the past ten years, and has had charge of all the engineering work. Refers to E. F. Allbright, H. F. Bryant, Benj. Fox, F. F. Jonsberg, J. T. Scully and H. C. Shiels.

WHITE, DAVID JOSEPH, Quincy, Mass. (Age 37, b. Quincy, Mass.) Educated in the public schools of Quincy and evening class in mechanical engineering at the Boston Y. M. C. A. From 1901 to 1904, draftsman and foreman, Quincy Quarries Co.; 1904 to 1909, general foreman and inspector with Ryan-Parker Construction Co., Stonington, Me., during the construction of Riverside Drive, New York, and steel and masonry piers for Manhattan Bridge, New York; 1910, in charge of cofferdam work for sea-wall of Ayer Mill in Merrimack River at Lawrence, Mass.; 1911, estimator with Cashman & Sons Co., Quincy, Mass., during the construction of Sandy Bay Breakwater, and various railroad and bridge contracts; and since 1911, with the Bay State Dredging & Contracting Co., and acting as general manager of that company; in 1918 served also as New England member of Emergency Dredging Committee, who had in charge the entire dredging program of the Government during the war. Refers to H. S. Adams, C. R. Gow, F. W. Hodgdon, C. H. Rogers, J. W. Rollins and W. F. Williams.

WOODS, WALTER AUGUSTINE, Somerville, Mass. (Age 24, b. Somerville Mass.) Student for two years at Lowell Institute, 1914-16, building course; one year at Franklin Union, 1916; one year I. C. S. course in railroad engineering, 1916-17; two years' course with Alexander Hamilton Institute on "Modern Business." Began work in 1913 with H. P. Converse & Co., as helper in drafting room; for one and a half months in 1914, on gas main plans for Arlington Gas Light Co.; in 1915 again with Converse & Co. in Baltimore as concrete form inspector, and from 1915 to date with the B. & M. R.R. as chainman, rodman, draftsman, water supervisor, inspector of bridges and buildings, etc., and at present assistant engineer on Terminal Division. Refers to E. P. Bliss, N. C. Burrill, S. P. Coffin, R. H. Parke, J. J. Rourke and S. E. Tinkham.

WRIGHT, FRANK VERNON, Salem, Mass. (Age 30, b. Hamilton, Mass.) Graduate of Connecticut State College in 1913, and since that date has been engaged in civil engineering work. This work has been, five and a half years on railroad engineering, six months on hydro-electric work, and the remainder on general engineering. For the last four years has been in charge of party on both surveys and construction; in 1913-14 on general engineering and road construction in Jamaica with the United Fruit Co.; 1915-16 with the B. & M. R.R.; 1916-17 with the Central R.R. of New York and the N. Y., N. H. & H. R.R.; 1917-18 with French & Hubbard and B. & M. R.R.; and since July, 1918, with the B. & A. R.R. as chief of party in charge of surveys relative to encroachments, land court and right-of-way construction. Refers to L. G. Brackett, Allen Curtis, T. P. Perkins and F. B. Rowell.

EMPLOYMENT BUREAU.

THE Board of Government maintains an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of positions available and the other of men available, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

514. Age 35. Two and one-half years' course at University of Maine in civil engineering. Experience, has acted as inspector for six months on sidewalk, sewer and paving construction; eighteen months as job engineer on various kinds of work; one year as assistant engineer on layout of water works, sewers, railroads and streets; six months as examiner of claims. Desires position as resident engineer on reinforced concrete building or water-front work.

516. Age 22. Graduate of technical college, studied in architectural engineering. Has had experience as rodman and draftsman. Desires position as transitman or assistant engineer.

517. Age 29. Has B.S. in civil engineering. Two years' experience on railroad work; two years in charge of construction work; one year superintendent of shop; nearly two years Corps of Engineers, U. S. Army. Desires position as office engineer.

518. Age 34. Graduate in mechanical and electrical engineering. Experience, two years machine and forge shops; four years drafting; two years chief draftsman; two years specification and sales; two years production officer (Capt.), U. S. Army; three years industrial engineering and management in manufacture of electric wire and cable. Desires position as industrial engineer or factory executive.

519. Age 64. Public-school education. Thirty-five years' experience as inspector on sewer construction, bridge and water reservoirs. Desires position as inspector.

LIST OF MEMBERS

ADDITIONS.

ETTER, HAROLD P.....	512 Commonwealth Ave., Boston, Mass.
HARSCH, ERWIN	65 Mt. Auburn St., Cambridge, Mass.
McCANN, FRANK J.....	135 Aiken Ave., Lowell, Mass.
MORGAN, GEORGE B.....	13 Waterhouse St., Cambridge 38, Mass.
SUTHERLAND, C. HALE	Mass. Inst. of Tech., Cambridge, Mass.

PROCEEDINGS.

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CHANGES OF ADDRESS.

BROWN, ALBERT F.....	36 Maxwell St., Boston 34, Mass.
CRANE, JACOB L., Jr., Robinson Hall, Harvard University, Cambridge, Mass.	
FALKENBERG, J. J.....	105 Gainsboro St., Suite 4, Boston, Mass.
FULLER, W. B.....	219 So. Central Ave., Eagle Rock, Calif.
LAWRENCE, BEARDSLEY.....	Box 268, Sharon, Mass.
MAWNEY, R. W.....	27 Park St., Room 4, Attleboro, Mass.
MORSE, W. F.....	10074 Keenan Park, Cleveland, Ohio
PARKE, ROBERT H.....	17 Thomas St., Fitchburg, Mass.
PARSONS, CHARLES S.....	908 City Hall Annex, Boston 9, Mass.
PRATT, DANIEL W.....	33 Wildwood St., Winchester, Mass.
REYNOLDS, DAVID S., 1114 Lawrence Bldg., 149 Tremont St., Boston, Mass.	
SANBORN, FRANK B.....	104 Commonwealth Ave., Boston, Mass.
SCULLY, JOHN T.....	Board of Trade Bldg., Central Sq., Cambridge, Mass.
STACKPOLE, M. R. . . .	Care of Maine Water Power Commission, Augusta, Me.
YOUNG, ERVING M.....	316 Huntington Ave., Room 332, Boston, Mass.

DEATHS.

GEORGE S. RICE	December 7, 1920
EDWARD A. FREEMAN	December 13, 1920

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Manual of Design and Installation of Forest Service Water Spray Dry Kiln. L. V. Teesdale. Bulletin 884.

Mineral Resources of United States. 1916. Part. 1. Metals.

Report of Governor of Panama Canal. June 30, 1920.

Water Supply Papers, Nos. 448, 452, 454, 455, 457, 458, 472 and 490-A.

State Reports.

Massachusetts. Attorney-General's Report. 1906.

Massachusetts. Report of Commission of Waterways and Public Lands. 1918.

Massachusetts. Railroad and Railway Laws. 1909.

New York. Report of State Board of Health. 1918. 2 vols.

Ohio. Uses of Hydraulic Cement. Frank Harvey Eno. Bulletin No. 2.

Ohio. Manufacture of Hydraulic Cements. A. V. Bleininge. Bulletin No. 3.

Washington. Columbia Basin Irrigation Project. 1920.

Municipal Reports.

Brockton, Mass. Report of Board of Survey, 1919.

Hartford, Conn. Report of Board of Water Comm'rs. 1919.

Lowell, Mass. Report of Commissioners of Water Works. 1919.

Melrose, Mass. Report of Public Works Department. 1919.

New York, N. Y. Report of Bureau of Buildings. Manhattan. 1919.

New Orleans, La. Report of Sewerage and Water Board. 1919.

Plainfield, N. J. Annual City Report. 1919.

Miscellaneous.

Proceedings of National Association of Railroad Tie Producers. April 19.

Reports on Mosquitoes, by North Shore Improvement Association.

Story of Massachusetts Committee on Public Safety. Geo. H. Lyman.

The following are the gift of R. H. Stearns:

Mecanique Appliquée Hydraulique. A. Flamant.

Roorkee Hydraulic Experiments. A. Cummings. 3 vols.

Water Supply of England and Wales. C. E. De Rance.

Water Supply. Report of C. O. Johnson.

Water Purification. Percy Frankland.

LIBRARY COMMITTEE.

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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
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BOSTON SOCIETY OF CIVIL ENGINEERS
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PAPERS AND DISCUSSIONS

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**WOOD AND CONCRETE PILING. — AN INFORMAL
DISCUSSION.**

BY CHARLES R. GOW, JAMES W. ROLLINS, FRANK W. HODGDON, HENRY F.
BRYANT, WRIGHT TAUSSIG, JOHN T. SCULLY, FREDERICK A. WALDRON,
AND HARRY E. SAWTELL.

(Presented October 20, 1920.)

CHARLES R. GOW.* — Although this is intended primarily to be an experience meeting, it would still seem permissible to introduce as a basis of discussion some of the fundamental theories involved in piling practice.

Piling, when used, is expected to transmit the load which is applied at its top, down through underlying strata of unsuitable material to some more satisfactory layer of soil which is capable of carrying the given load safely.

If this latter stratum is composed of rock, or of material approximating rock in hardness, the piling becomes to all intents and purposes a series of wooden bearing columns supported against lateral displacement by the surrounding earth. In the usual case, however, the piles do not reach such a hard bottom, but for practical and economic reasons are stopped when their tips have penetrated a satisfactory distance into some natural deposit or combination of sand, gravel or clay of sufficient density to offer a considerable resistance to further driving. These piles cannot be considered as mere columns, because the soil immediately under their tips is incapable in itself of support-

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ing the entire load without greatly exceeding its bearing capacity. Such piles are known as friction piles because, in the process of driving, the surrounding soil is compressed and a resulting reaction set up which causes the earth to grip the exterior surface of the pile with such frictional intensity that the surrounding ground itself is stressed and the greater portion of the load transmitted to it.

The shape of the mass of soil so stressed by the pile is that of a surrounding elongated cone with the pile occupying its vertical axis, and the effect so far as support is concerned is the same as if the cone were a solid body with the load applied at its apex and uniformly distributed by its base upon the horizontal plane at the level of the pile tip. It will be seen, therefore, that such a pile will carry all the load that is capable of being supported on the area of distribution by the underlying soil. This area will vary as the cone base varies, and that dimension in turn depends upon the amount of frictional intensity of contact which exists between the outer pile surface and the adjacent soil.

A soft and easily compressible soil will offer much less frictional resistance than will a dense or compact material. Consequently in such a soil the pile must be driven to a greater depth in order to obtain the same area of distribution at the pile tip level which would obtain in the denser material.

Assuming, then, that a given load has to be carried by a certain cluster of piles, it is essential that the soil at the horizontal plane of the pile tips should be capable of supporting a uniformly distributed load of this amount. Otherwise settlement will result. Obviously, also, if there exists other material below this plane which is incapable of supporting such a load, failure must result, due to its yielding under the superimposed pressure.

A test load applied to a single pile sometimes gives misleading results because the cone of distribution may spread the load over a large area and thereby produce a low unit intensity of pressure upon the soil at the tip level. Unless the next adjacent pile is spaced at a sufficient distance from the first to prevent the two cone bases from overlapping, a double loading of the soil will result on the area occupied jointly, and the material may possibly be overloaded.

Under the most favorable conditions it is not desirable to drive adjacent piles closer than two feet on center, because the pressure cones are almost sure to intersect one another. Such a spacing allows 4 sq. ft. of horizontal area at the tip level upon which to distribute the load carried by the pile. As the soil decreases in bearing capacity, the spacing should be increased so as to allow a larger area of distribution for each pile.

Taking up now the practical side of the question, there may be mentioned several features not usually treated by textbooks on the subject, which are of more or less importance.

The question of whether or not piles can be successfully driven through certain classes of soils is one upon which there is much disagreement. In an experience covering several years, during which the speaker has had occasion to excavate to considerable depth in various sections of this locality, he has been impressed with the great number of instances where broken or damaged piles have been uncovered. Especially has this condition been noticeable in those districts where there exist considerable deposits of coarse gravel filling, through which the piles must penetrate in order to reach the natural underlying soils. Take for example the section known as the Park Square railroad property. This area was formerly a portion of the Back Bay marshes. The flats were reclaimed by depositing over them gravel filling to a depth of from 15 to 18 ft. The original surface was of mud extending to a depth of from 15 or 18 ft. more, and was underlaid with a natural deposit of blue clay into which piling must be driven in order to obtain a satisfactory bearing. The gravel filling has been thoroughly consolidated, so that it would probably offer a satisfactory resistance against settlement under ordinary conditions of loading were it not for the existence of the silt below it which renders the use of some form of piling absolutely necessary. To penetrate the silt a pile must first be driven through this upper layer of coarse gravel, where great difficulty is encountered.

Observation of many piles uncovered in this general locality indicates that a very large proportion of the piles fail to penetrate this gravel stratum. Apparently, the pile tip as it advances through the gravel carries ahead of it a large number of stones

and pebbles which ultimately are gathered into an enlarged mass, preventing further penetration. Further driving usually results in some form of damage to the piles. Sometimes the tip is broomed and mushroomed into a mass of crushed fiber; again the pile may fail by diagonal shear or by telescoping one part upon another; frequently these piles are found with their lower portions broken off and deflected laterally almost at right angles.

In one case, in which the speaker encountered difficulty in driving piles through this material, the trouble was overcome by sharpening the pile tips almost to a point, so that the several stones encountered would be deflected to one side and not carried down in advance as in the case of the ordinary tip.

There are many authorities who claim that wooden piles can be successfully driven through stone rip-rap. The speaker has uncovered a number of piles in his experience which have been driven into rip-rap but never has he found one which has penetrated such material for any considerable depth. In such cases the tips of the piles are soon deflected in one direction or another, as they encounter the inclined surface of the stones constituting the rip-rap, with the result that they become broken and broomed into a mass of pulp. It is probably true that such piles obtain a sufficient hold by means of this brooming so as to maintain them in place, but if there is unsuitable foundation material under the rip-rap the piles will be of no assistance in overcoming its effects.

A very common cause of failure on the part of piling to carry its load is the stopping of the piles before good bottom is reached. In many instances such piles develop apparent resistances to further driving due to the high frictional units developed in some of the upper layers of soil penetrated. This may easily lead to the assumption that the pile has brought up in good soil, when as a matter of fact the tip still remains in poor material. Under such circumstances the load applied to the pile is transmitted to the layer of filling possessing the high frictional value and is further distributed by this stratum on to the soft underlying soil which slowly yields under the pressure, causing ultimate settlement of the structure.

There is a mistaken notion on the part of many people that

an otherwise poor soil is rendered capable of supporting permanent loads by merely driving piles into it. It should be understood, however, that it is the penetration of the pile into good material which gives it its supporting power.

When the pile tip brings up in a sandy or gravelly soil there is usually no difficulty in securing the necessary resistance required to carry the load safely. When, however, the supporting medium is of clay, there is often some question as to when it is safe to stop driving. Clays are usually of a plastic nature, and generally speaking are apt to be stiffer when first encountered than at a greater depth. It is usually possible to drive piles into clay to any desired distance with little variation in penetrations under successive blows. It is also commonly found in this locality that in attempting to apply the *Engineering News* formula to such cases, they frequently do not give satisfactory results. If, however, the pile is permitted to remain undisturbed for a few hours, it will require several additional blows to produce again the original penetration, and if the formula is applied to these re-driving results very high load values will usually be obtained. In explanation of this phenomenon it may be said that during the original driving a rough and irregularly shaped hole is made in the clay by the projecting surfaces of the pile. As soon as driving ceases, the clay closes in around the pile, completely filling each depression and crevice, and gripping the pile surface so firmly as to offer an enormous resistance to further penetration.

During the construction of a pile wharf at the Boston Army Supply Base, some long piles were found extremely deficient in carrying power by the usual application of the driving formula. One 40-ft. pile when driven to grade gave a 10-in. penetration, indicating a safe carrying capacity of only 4 tons, whereas it was designed to carry 15 tons. A test load applied to this pile showed no settlement at 12 tons and only a slight settlement at 18 tons. The 12-ton load was adopted, and has since been carried without any indication of overloading.

Similar conditions were encountered in driving foundation piling for the wet slips of the Victory Destroyer Plant at Squantum. Piles which gave values of not more than 2 to 3 tons by

application of *Engineering News* formula subsequently supported test loads of 10 to 12 tons without appreciable settlement.

A more recent example of similar behavior of piling driven into soft clay was noted in connection with the pile-driving operation at the new John Hancock Building in the Back Bay district. In this case many piles gave initial penetration values for last blows of from 5 to 7 ins., whereas re-driving tests after a set of twenty-four hours reduced these figures to from $\frac{1}{8}$ to $\frac{3}{4}$ in.

All of the instances cited show that the usual driving formula is very conservative when applied to the soft clays of this locality. Of course the greater the depth of embedment which a pile has in such clays, the more certain one may be as to its sufficiency.

Vibration may often be an aid to the settlement of piles, and its effects should be guarded against. When structures are subject to vibratory forces the impulses may readily be transmitted to supporting piles, and in such cases piling which has successfully carried its designed static load may yield under the influence of the vibrations which tend to disturb and alter the condition of the soil immediately adjacent to the piles. Under such circumstances, deeper penetration and lighter loading are indicated as probably desirable.

The splicing of piles where extremely long sticks are required is often necessary or desirable. The joint between the sections may be secured by a variety of methods. An ordinary carpenter's splice, when the ends are halved into one another and bolted, probably gives the strongest and also the most expensive splice. A simple metal sleeve if of sufficient length and thickness is also effective. Oftentimes the two ends are butted together and spliced with outside cleats, just as splints might be applied. In some cases no other precautions are taken than to dowel the two ends together, using the top section as a follower to drive the advance section.

If the spliced pile is driven in a perfectly straight line and the soil is such as to introduce no deflecting forces, such piling can usually be successfully driven, regardless of the type of splice used. If, however, the driving is difficult and there are tendencies which cause the pile to deviate from a straight line during

the process of driving, the splice must be as strong as the balance of the pile or failure at this point is likely to result.

When long piles are driven in very soft material, and additional resistance is required beyond that developed, the result may usually be accomplished by lagging the pile vertically with 2-in. by 4-in. or 4-in. by 6-in. strips bolted to it. This serves to increase the surface exposed to frictional contact with the soil and likewise produces added compression in the surrounding soil because of the greater displacement.

Sometimes it becomes necessary to drive piles through water in locations where the bottom is difficult to penetrate. Such piles may be rendered stable by depositing rip-rap around them. In other similar cases it may be desirable to remove the hard material by dredging and to backfill the space after the piles have been driven.

The use of a follower in driving piles is not always deemed satisfactory, but there are many cases where its use may be beneficial. In driving into clay or plastic soils, it is usually possible to bring the pile heads to any desired elevation, because in such soils the resistance seldom reaches the point of absolute refusal. A follower may sometimes be used in such cases, allowing the pile to be driven from the original surface and its head stopped at the desired grade, eliminating the cutting of the piles and permitting the pile driving to proceed the excavation. This method was successfully adopted some years ago during the construction of the Metropolitan High Level Sewer at Hough's Neck, Quincy. The same piling contractor later drove foundation piling for a section of sewer in Chelsea, the driving being followed down through a considerable depth of silt which closed in and filled the hole after the follower was withdrawn. A compressed air tunnel was subsequently driven over these piles, and a masonry sewer constructed, for which the piles served the purpose of a foundation.

JAMES W. ROLLINS.* — Colonel Gow has most thoroughly discussed the theory of pile driving, and therefore I shall limit myself to a practical talk based on our experience in driving many thousand piles under almost every possible condition.

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Most engineers want to drive piles to meet some favored formulæ — none of which in my judgment is based on any practical theory, nor do I think any reliable formula can be made. The conditions under which piles are driven vary so, that no reliable formula can be deduced from the results.

For instance, some clays offer but little resistance to driving, but after twenty-four or thirty-six hours develop perfectly satisfactory "set." Other clays, apparently of the same consistency, do not develop any "set."

A 6-in. tip small pile can be driven through stiff clay, while a heavy 8-in. tip pile is driven with difficulty, and as most requirements are as to lengths, great confusion, expense and delay is occasioned by the demand of an inspector for an average 1-in. penetration for the last five blows.

Again, gravel or sand offers great resistance and often impenetrability to piles, and figures according to the formulæ good for tremendous loads, but if driven in water for a railroad trestle the vibration of the pile will cause a jetting action and the piles may settle.

I think I can say conservatively that we have driven many more piles which would not, as compared with those that would, meet the conditions of any formula at the time of driving.

In most clays a final penetration of 4 ins. to 6 ins. is about all that can practically be obtained. The writer saw many piles driven in the South Bay district of Boston which would go two feet or more under the last blow, but never knew of any trouble on account of settlement, unless, as in the Back Bay and Charles River district, the whole country settled.

There are some conditions under which piles are driven which may, in the opinion of the writer, make trouble; for instance, in driving through gravel strata, over 3 or 4 ft. thick, into a soft stratum, which again overlies a hard stratum.

Such a condition existed at Cambridge Bridge, where the bottom was clay, 8 ft. of gravel, more clay, and again gravel, into which it was necessary to drive the piles. We got into difficulty right off, though we used selected, straight, heavy sticks, and shod them with cast-iron points (no good, by the way). After a few piles had been driven it became impossible

to get many of the piles through the gravel, and those that did go through went with such difficulty that we never knew where the point was, though the head went down. Finally the engineers adopted the only safe way in a condition like this and dredged the gravel out, drove the piles, then put the gravel back. Engineers and inspectors often do not realize that though the head of a pile is going all right the tip may be in shreds, or broken off; and softwood piles will not stand heavy hammering.

Water jets are used with success in driving piles through sand, and to some extent through gravel, but in the latter case a powerful jet with a great volume of water must be used to get satisfactory results.

Steam hammers have been developed, and with some success, but our experience with them has not been satisfactory, except in the use of the old "Vulcan hammer," which is not steam driven, but only raised by steam and dropped. The regular steam hammers will not stand up under heavy driving, and the consequent wear of the iron ram against an iron plate, and it is either necessary to have two or three hammers at hand or lose much time in waiting for repairs. They do good work particularly in hard driving in sand, gravel and stiff clay.

In the last few years steel sheeting has been extensively used, and can best be driven with a steam hammer. To pull this sheeting a steam hammer is used in "*reverse*" with great success.

To drive piles under water various devices have been used. One consists in driving a pile through a spout of iron, lowering the spout to the bottom and having the hammer work through it. Another consists of extension leads, with a follower guided in these leads, the bottom end of the pile being held in the lower end of the leads with two "knives," which sink into the wood as the pile is driven, while the top of the pile is in a hollow casting on the end of the follower. We have driven many piles 40 ft. under the water level with such a machine, with great success.

As to cost of pile driving, a good machine with crew is worth to-day about \$100.00 a day. An average day's work is about 25 piles; making cost of driving alone about \$4.00 a stick. We have driven 230 piles in a little less than ten hours, and 120 piles in

four hours; the latter work for a conduit in Charles River Basin.

When long piles are required, either yellow pine or Oregon fir may be used, even up to 100 ft. in length, or piles may be spliced. Some engineers splice piles by driving the first length, sawing it off, putting a $1\frac{1}{2}$ -in. dowel 18 ins. long, 9 ins. into each length, then putting a splice pipe about 24 ins. long over the joint, driving the top section of the pile into the splice. Another way is to use four pieces of lagging 4 ins. by 6 ins., 15 ft. long, bolted through the piles at joint. When piles drive easy, much increased holding power can be obtained by lagging the piles as just described. This method is used extensively in pier construction in New York Harbor.

In clay driving, suitable allowance (not less than 2 ft.) should be made for the displacement of the clay by the piles, and the consequent "raising" of the bottom.

A dangerous condition may develop, especially on masonry or other structures subject to a lateral thrust, when piles are driven through a very soft bottom on to a hard bottom. Piles in this case have no lateral stability, and this stability should be maintained by dredging out some of the soft material, driving the piles, and then filling up to plan level with crushed stone or fine rip-rap.

In water subject to the action of "teredo," great care must be taken to protect the piles, completely covering the piles with gravel and sand filling.

The writer cannot agree with the proposition that ordinary foundation piles can be driven through rip-rap; as the results of driving through gravel and subsequent excavation, exposing the pile tips, show broomed, broken, and shredded piles, it seems incredible that any attempt to drive through rip-rap would not meet with a more general destruction of the pile tip.

Do not think, when a pile reacts from the blow of a hammer, which in the writer's opinion means a crippled pile, that because the head goes down, the tip is also going down in *good condition*. Many failures result from overdriving and consequent crippling of piles.

Having criticized all formulæ, it is pertinent to suggest some safeguard, and the only one the writer can suggest is, in ques-

tionable driving, where a 40-ft. pile or a 75-ft. will not bring up, that a period of "set" be allowed — forty-eight hours — and a new test made, and the result of the first two blows observed. If a set is obtained, all is well. If no set is found, additional piles or larger ones must be driven. But there is a safeguard in the fact that *age* will give strength — and seldom is a pile subjected to its ultimate load until many days after driving.

FRANK W. HODGDON.* — I will give you a little of my experience with actual pile driving. My first experience in pile driving was to make a contract to build a pile wharf. I never had seen a pile driver in use and had to study about the matter. That was in 1878. The pile drivers used what were very light hammers comparatively, and they used nippers to catch the hammer to be raised to the top of the gins, and there a man broke the hold of the nippers and let the hammer come down with full force. Those light hammers working on heavy piles would be run up to the top of the gins and then allowed to come down with full force, with the result that many of the piles would be split. Later the present scheme was adopted of attaching a rope directly to the hammer and using a friction clutch so as to let the hammer when it dropped unreel a drum and use a shorter blow, so as not to break the pile. The heavier the hammer used the better it is for pile driving. Mr. Rollins has stated that on some of our work he pushed the piles right down to grade or perhaps hit them once. At the time we started that work an ordinary pile driver had been in use on same job, and with this apparatus penetration of about 15 ft. in clay was obtained. The inspector called up our office and said there was no bottom; that the pile was going down at one blow. We asked the weight of the hammer, found that it was eleven tons, and told him that if it is stopping an 11-ton hammer surely it will hold up 10 tons, which is all we expect the pile to do. We had some that didn't go quite down, and we let a pile stand over night and then put on the drop hammer. The set had begun and it took a number of blows to start the pile. With regard to the question of set in the clay, you can get a good idea from this experience. We

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drive a good many wooden bulkheads, piles being 6 ft. apart. The mud that the pile goes into is this same clay which, after it has been dredged, dumped, and rehandled is pretty fluid and will run out on a slope of from 12 to 25 horizontal to 1 vertical. There is a good deal of almost fluid pressure against these bulkheads which pushes the vertical piles back on to the spur piles. We had a great many bulkheads fail in this way. In this particular place the original section of bulkhead had been built more than a year previously to the time it was filled. A gap had been left in the bulkhead to allow scows to float in and out, and it was closed up about a year later than the time the original section, with the same workmanship as the original bulkhead. In the gaps some of the main piles pulled up, but in the original bulkhead they all stayed down and the bulkhead stood. It was simply that those piles in the original bulkhead had been down long enough for the piles to bed in the clay and become thoroughly set. We figure, as a rule, to get piles down about 15 ft. in ordinary clay. Ordinarily clay varies to a considerable extent, and a little less than 15 ft. would probably be sufficient for an ordinary building pile, but for a bulkhead pile the spur piles should be driven perhaps 10 ft. and the main piles 5 ft. more, in order to get a grip in the clay. Due to this grip on the piles the foundation gets better and better every year. We have a great many cases where it is desired to withdraw piles to get them out of the way, and they can't be started until the grip is broken by striking them with a hammer.

Another use for piles is for compressing the material. We had a case where we had a sea wall built on clay. The load behind it was so heavy that it began to move. We found that the trouble was due to a soft spot in the clay, and that the wall was settling into it and moving out. To stop it we took the pile driver and drove piles down in front of the wall where the bottom of the dock was about 25 ft. below low water. We drove a row of piles about 4 ft. in front of the toe of the wall. They went down very easily. Some went 30 or 40 ft. below the bottom of the dock. Then we drove another row inside between the toe of the wall and the first row, and it took heavy driving. That was simply because the material had been compacted by

the first row, and the second row shoved in gave support to the toe of the wall. In the matter of securing support in very soft material, clay or silt, I might mention a case at East Boston where the contractor used the longest piles available and where they apparently went down full depth, but it was in a material so soft that we were practically sure they would settle when loaded. So we took 6-in. square timber about 20 ft. long and put it on the end of a 60-ft. pile; took strips 4 ins. by 6 ins., 20 ft. long, and bolted them on four sides of the piles; drove these 80-ft. spliced piles down and got very good results. All this lagging, bolts and all, was driven down below the bottom of the dock, so that the whole thing was buried in the supporting earth. They were held together thoroughly. There was no chance for them to slip off of the dowell, as Colonel Gow suggested has happened in several cases.

Speaking of the supporting power of piles, one contractor on the very first job I ever did told me he was building a bridge for the old Eastern Railroad, just over the line in Maine. On account of a soft bottom the longest piles the railroad could obtain anywhere were used. He said that at the last blow of the hammer they went down 2 ft., and he reported back to the superintendent, who said, "We've got to drive them as they are the longest we can get." This contractor said he made a pilgrimage to that bridge once a year for over five years, and that there had been no settlement. The formula would probably not have allowed much load on it. Yet a railroad went over it, and it was an ordinary pile trestle bridge.

I have had very little experience with rip-rap. I had to drive piles into it to support a portion of a pile platform in front of a wall. The rip-rap, which varied in depth from 12 to 20 ft., was mostly granite quarry or stoneyard chips, not very large and dumped from a scow. We started driving in that, although we didn't care to drive really through it. The rip-rap was put on top of the clay and spread the load on that clay. That would carry the wharf, but every pile went down. They went pretty crooked at times. They stood all kinds of ways, but they were limber enough to come up into place again. One of them didn't go at all. We finally simply sharpened it to a sharp wedge, put on a piece of iron in the shape of a V spiked on to the end. It

didn't go straight but wiggled down in between the stones. The wharf built on these piles has been in use forty years without renewing the piles. Driving sheet piling is another art. It works all right in soft material but, if any rocky or hard material is met, one can almost always count on its twisting and throwing the sheeting out. Into our clay you can drive four or five feet, enough to build any bulkhead or cofferdam without trouble, but you ought not to try to drive any depth, because you are sure to break the piles and put them out of business.

HENRY F. BRYANT.*—The theory of pile driving, as expressed in existing formulæ, does not seem to be very much in favor to-night. Nevertheless, I am going to give you a simple formula of my own. We all agree, I think, that the *Engineering News* formula is as good as, perhaps better than, any, but not of universal use.

In cases where you can start driving in or near soft material and drive through this some distance into sand, light gravel or firm clay, that formula gives good and safe results. Where the supporting stratum is soft and easily penetrated for considerable depths, the formula fails to indicate a reasonable fraction of the actual capacity shown by tests. Similarly, resting piles on rock or impenetrable earth strata may give a bearing value by formula much in excess of actual.

Mr. Gow mentioned the danger of leaving the pile tip on the surface of hard bottom, particularly when the upper portions are in fill or hard earth overlying soft material. In such cases the driving friction in the top layer plus the end bearing may compute safe according to the formula, whereas such a pile is certain to fail long before one with much greater penetration under the last blow, which has no firm top crust to seize the pile and add its great weight to it as the soft layer shrinks. I think the *Engineering News* formula, or any other which depends on penetration in such cases, is utterly useless.

Now, my contribution of theory is simply this: in cases of ordinary spruce, loblolly or other similar piles driven into bearing soil which can be safely penetrated, provide one lineal foot of penetration into such soil for each ton of load which the top of that pile is to carry.

* Engineer, 334 Washington Street., Brookline, Mass.

This, of course, excludes piles resting in liquid clays or silts which do not appreciably "set" on the pile after it is driven.

The basis of this rule is that side friction rather than tip bearing is the effective supporting agent. Pulling tests of piles have shown a yield point of about 2 000 lbs. per square foot of embedded surface, and, adopting one half this as the safe working figure, we have for an 8-ins. pile, neglecting the tip, a surface per lineal foot of approximately 2 sq. ft., which at 1 000 lbs. per sq. ft. gives us our 1-ton capacity.

Tests and many years' experience show this rule to be reliable.

In the case of larger piles, such as the 16-in. cast-in-place concrete piles, the theory holds equally well, giving a capacity of 2 tons per lin. ft. of penetration.

I think Colonel Gow will remember some concrete piles recently driven where we sought a carrying capacity of 30 tons with a penetration of 15 ft. into sand bottom. A test by the City Building Department developed a yield point of 55 tons under the code, which is reasonably close to our theory.

I would mention another feature about the use of the *Engineering News* formula, or any other which involves the factors of hammer blow and penetration. In using this formula, you may get an apparent final penetration when driving in hard material — let us say of $\frac{1}{2}$ in. If you go away twenty-four hours, you will find on your return that the pile has apparently come up. This I believe is due to compression in driving. Possibly some is due to brooming, and the broomed fiber straightens out somewhat. In testing piles under static loads, I have seen spruce piles compress in the same way.

Mr. Gow speaks of the earth loading on top of the piles in Park Square. In that locality, some of the piles have been well driven, not overdriven; nevertheless, they have gone down. Perhaps some of the Subway engineers here know about this. These piles, in some cases at least, have settled slightly, and in my judgement this settlement is due solely to the superimposed load of filling which is so hard to penetrate or follow through.

In splicing piles I do not like to take chances, and that is what I think one does if one uses simple center dowels as the

sole splice. I do not know that I ever remember seeing piles of any length driven on a dowel that didn't separate before reaching bottom. I may be wrong, but I recommend and use a pipe ring or collar 12 to 24 ins. long, placed over the head of one pile and receiving the tip of another pile put in it. I have just driven some 80 ft. piles that way and have stood some heavy buildings on them in very soft material. I have never found reason to fear any weakness except that from lateral pressure, and that is quite remote.

JOHN T. SCULLY.*—I have had some years' experience in the driving of wood piles, and I have noticed many times the brooming of piles. Often a young engineer has insisted on driving, in order to arrive at the penetration which the specifications called for, while in my judgment the pile was being broomed. I have seen many piles pulled up after such driving and found the point of the piles to be battered and broomed.

About driving through rip-rap, — there is great uncertainty as to the value of the wood pile after it has been driven into or through rip-rap. I have pointed the piles and found it as satisfactory as using steel shoes in penetrating a gravel or rip-rap stratum. The wood pile does not seem to me to be the proper pile to drive in such a case.

I think, Mr. Chairman, we ought not to limit our discussion altogether to wood piles. I have particular reason for saying this because I am interested in a concrete pile. Colonel Gow spoke of the hard stratum, or gravel, or compact sand through which it is almost impossible to drive a wood pile. I have found that, with MacArthur pile apparatus, it is possible to drive the steel pipe and plunger through a very stiff stratum of gravel or sand. If it is impossible to drive the plunger and tube through a layer of rip-rap or gravel, the plunger is removed and a batch of concrete is put into the tube. The plunger is then lowered into the tube and the steam hammer pounds on the plunger which forces the concrete at the bottom of the tube into the spaces in the rip-rap or gravel. The hammer and the plunger weigh about 5 tons, so you can imagine that there must be a fairly good concrete base at the bottom of the tube. After the

* John T. Scully, Inc., Cambridge, Mass.

bulb or footing is made, the plunger is again removed and the tube filled with concrete; the plunger is then put on top of the column of concrete and allowed to settle as the tube is withdrawn. This operation forces the concrete into any voids that may be left after the shell is removed.

It is sometimes argued that, if a pile reached a proper bearing stratum, a bulb or pedestal would not be necessary. It is not uncommon, however, to find it impossible to reach the stratum intended. In this case it seems to me very desirable to force this concrete into the soil.

HARRY E. SAWTELL.*—There seems to be a great deal of harmony of opinions in regard to the limitations of the *Engineering News* formula. I have one or two notes along the same lines which I wish to add to what has already been said.

It seems to me that the use of the formula should be limited to conditions where the material is of uniform consistency, and neither very hard nor very soft, such as stiff clay or loose, fine water-filled sand.

Our load tests seem to indicate that when those conditions obtain, it is proper to use the *Engineering News* formula at its value.

There are, however, many things which seem to modify it distinctly. For instance, the size of the particles composing the material into or through which the piles are being driven; the character of the fill or other material through which it is necessary to drive the piles in order to reach the desired stratum; the degree of compactness of the material, and degree of moisture. These are among the most important factors to consider.

We have made many driving and load tests on piles driven into what we call "medium clay," and where the embedments were of varying depths, and we have found that with about 18 ft. embedment, after the piles have set for, say, forty-eight hours, they will carry, without appreciable settlement, a load fully 50 per cent. greater than that indicated by the *Engineering News* formula at the time of driving. For greater embedments than 18 ft. the increase in load-carrying value is somewhat greater, that is, for medium clay. The increase in value for soft clay is

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much greater, due to the low value found during driving. Mr. Rollins and Colonel Gow have given you examples of that.

The *Engineering News* formula is, of course, a friction formula, and the frictional values of different soils vary greatly.

The best procedure, where piles are to be driven through various kinds of unsuitable material to a hard, suitable stratum, is to drive average-sized piles in different portions of the site through different typical soils, as shown by borings, driving them to various selected tonnages by *Engineering News* formula, then pull the piles and see if any damage has been done. You will thus have positive evidence as to just how hard the piles can be driven without hurting them and still have them well seated. Having this evidence, use the formula as a gage, and the piles can be driven with a reasonable degree of certainty with reference to their condition and proper seating.

Opinions differ as to what well seating is, owing to the varying kinds of soil. A true value of the load-carrying capacity of piles cannot be obtained except by load testing them. All jobs will not permit these tests to be made, but they should be made on all important foundation jobs where piles are necessary.

We have recently had an opportunity of making many tests of piles having practically point bearing. The piles had to penetrate material of various kinds, finally bringing up in a hard stratum on or in which we wished to support the loads. By driving and pulling piles and by re-driving and load tests, we found that a steam hammer, either 3 000 lbs. or 5 000 lbs., could drive hard-pine piles of about 12 ins butt and 7 ins. to 8 ins. tip, to a formula value of 25 tons, and a drop hammer to a value of about 20 tons, without injuring them. If soft woods are being driven, the safe values are 5 tons less than for hard woods. We then used the formula as a gage, and are getting a very satisfactory job of piling, feeling sure that the piles are well seated and that the percentage of injured piles is very small.

Under some conditions it is very easy to over-drive a pile and spoil it.

I have noted many times that engineers, inspectors, also pile-driver foremen who thought they knew all about pile driving, could not tell correctly whether piles after driving were good or bad.

Fortunately, we had an opportunity to load test and pull piles which had been pronounced good by inspectors and pile-driving foremen. We were driving spruce piles into a gravel bed. Everybody on the job knew that some were bad, but 50 per cent. were pronounced to be good. After load testing, we pulled them and found all but one badly broken and broomed.

They held up quite a load under test. Not as much as was designed, but quite a load; but as the load was increased there would be a rapid settlement. Then they held for awhile and began settling again. In fact, they performed bad stunts in settlement, due to brooming, sponging and packing of the gravel at points.

Another interesting thing we have observed is that it makes a great difference in results obtained if the driving block used in steam hammers is new or mashed up and spongy from long use.

The mashed-up block acts as an absorbant of the energy delivered by the falling ram. This reduces the penetration of the piles and increases the resulting tonnage. A change from an old block to a new one in one instance immediately reduced the value, according to formula, one half.

Some piles show a greater tendency to split than others. Red oak will split more readily than white oak, especially in cold weather when they are full of frost. This has been noted a number of times by our representatives; also, that in such cases drop hammers are harder on such piles than steam hammers.

It would be well to state here that we have found to be true the statement that steam hammers can sometimes drive piles through hard material without injury, when drop hammers cannot. I do believe, however, that more accurate results can be obtained from the use of drop hammers than from steam hammers, especially in pile testing.

I have had an opportunity of re-driving a large number of piles and of comparing their new value with that obtained at first driving, and I have also had these piles loaded, especially those in medium clay, and we find that the actual safe loads, according to load tests, do not correspond either to the original or re-driving formula value.

Generally, the first blows of re-driving will give a very high value, but afterward, as a rule, it comes back to the original values, or corresponds to it.

The load tests generally show that where the piles are embedded, in medium or soft clay, and the load placed upon the pile is greater than the working load, and it is allowed to stay on for a considerable length of time, that there is a slow but pretty sure settlement.

Where piles are driven through a fill or soft material superimposed on a hard stratum of very compact sand, as is often the case, and also drive through the compact sand, it will have a tendency to flow in a horizontal direction instead of upward or downward. This horizontal displacement will, in the case of cast-in-place piles, be very likely to pinch them in and reduce their cross-section.

On a recent job, we had occasion to load test some concrete piles of the cast-in-place type, Raymond piles, and the test acted very curiously. We decided to have the piles dug out, and found on doing so that we had by chance picked out and tested piles which had been badly pinched in, as I have described, and due to a thin stratum of very dense, hard sand through which the piles had been driven and which had simply been pushed to one side by the driving. Afterward a jet was used and no further trouble encountered.

Another interesting thing which has come under our observation in regard to concrete piles is a method of heating the concrete in the mixer during cold weather, and the results of that heating. The contractor used a kerosene torch which threw the flame right into the mixer. It was so designed and set that the flame did not reach the concrete but came very close to it, and it heated the air in the mixer to a high temperature. Not having seen this before, I thought I would find out what effect it had on the concrete.

I had 6 cylinders made 8 ins. by 16 ins. high and sent to the Massachusetts Institute of Technology. Three were of the hot material taken right from the discharge as it was put into the shells, and three were from material treated in the ordinary way to remove frost only. The 6 cylinders were crushed at the

end of twenty-eight days, and in every case the cylinders made from the material heated in the mixer by the gas flame as described showed a very marked reduction in crushing strength. The average reduction was 44 per cent. I don't know whether that has been the experience of anybody else or not. It is probably not safe to say that the results would always be the same. It would be interesting to try it out again. I hope somebody else will. I shall try it again when an opportunity offers.

J. WRIGHT TAUSSIG.* — You have heard a great deal, this evening, concerning the difficulties and uncertainties of driving wood piles. In many cases mentioned, wood piles have either broken in driving or been broomed at the point by over-driving, so that their ultimate supporting value is quite doubtful. Much difficulty has also been found in securing proper penetration with wood piles, and in knowing what safe value could be assigned to them after they had been placed.

Concrete piles were introduced to eliminate the uncertainties of the ordinary wood pile, and they have done more than this in many instances, since their use provides not only a safe foundation, but often an economical one. Some people seem to think that the use of concrete piles eliminates all difficulty or uncertainties, but we know this is not the case. Structurally they do satisfy most engineers' requirements, but the matter of loading must be carefully and intelligently investigated for each particular case. This requires an expert and experienced organization to install even the most perfect concrete pile.

Aside from pre-cast concrete piles, which have very limited possibilities, Raymond concrete piles are the type most widely known and used. In developing this pile, the Raymond Company has concentrated along two general lines:

First, to secure a concrete pile structurally perfect under any conditions.

Second, to acquire information and perfect its engineers in interpreting such information, so that adequate and economical foundations can be installed.

Structurally, the concrete pile molded in a steel shell, which

* 140 Cedar Street, New York, N. Y.

is permanently left in the ground, answers all reasonable requirements for safety. Mr. Balsell has mentioned the fact that, where rocks or cemented hardpan exists in the ground, these hard bodies may be forced through the steel shell by the driving of adjacent piles. This we know is possible, since it would be economically impossible to use steel shells of sufficient strength to resist this unusual and peculiar condition. If hard material penetrates the shell, either before or after filling with concrete, it can either be seen from the surface or deduced from the fact that the concrete is forced out of the shell at the top. In either event, corrective measures, to secure a perfect pile, are taken.

The question of deciding on proper loading, and the interpretation of information secured on particular jobs, has received a great deal of attention and requires much further study before definite recommendations can be made. It is doubtful whether engineers will ever be able to formulate rules applicable to all conditions.

My feeling is that more information than is usually secured should be obtained before deciding on the foundations. Careful borings should be taken which, with other information available, may be used in forming conclusions. Too much care cannot be taken in interpreting this information, as soil of similar characteristics often gives entirely different results as far as pile loadings are concerned.

For instance, I have seen cases in which a pile has a final penetration of 1 ft. to the last blow, whereas on re-driving, after standing over night, only 1 in. will be secured to the last blow. Under similar soil conditions, I have seen piles driven which, after standing over night, secured the same penetration to the last blow as that secured the previous day.

In St. Louis, Raymond piles, driven 4 or 5 ins. to the last blow with a No. 1 Vulcan hammer, were driven further on succeeding days without appreciable increase on the final penetration. This would indicate a very low loading value, but six months after driving one of these piles was tested, under an actual load of 60 tons, with a total settlement of less than $\frac{1}{8}$ in.

It has also been found that piles which "tighten up" after

standing usually support greater loads than those which fail to show this characteristic. This is not always the case, however, and it is very difficult to determine what relation the second driving bears to the supporting value of the pile. In other words, the *Engineering News* formula is usually considered safe only when applied to the original driving.

The *Engineering News* formula is supposed to have a safety factor of 6. Actual tests made in a number of locations indicated that it has a safety factor of at least 2, but if the final penetration used in this formula is taken after the pile has set over night, there are grave doubts as to whether any safety factor is left in the formula.

The use of concrete piles in Boston is peculiar, in that you have soil here more or less firm near the surface, which is underlain by material susceptible of compression, — peat or bog, or whatever it is called. Any engineer knows that if you support a load in a material underlain by a compressible substance, you are apt to get settlement, so that whether wood piles, concrete piles, or short caissons are used, the load must either be carried through the compressible material, or distributed sufficiently to insure small and equal settlement.

Your conditions here in Boston require careful borings in most cases, and I strongly recommend that this practice be more universally adopted.

The question has been raised as to the practicability of driving piles through rip-rap: This would appear to be impracticable, except in rare instances. Where the rip-rap is not a comparatively thin layer and underlain by soft material, it is usually impossible to penetrate it with piles.

In New York it is quite customary to drive wood piles on the river piers through previously deposited rip-rap, which furnishes additional stability for the piles which penetrate very soft mud. Great care must be taken not to break wood piles, as it is very difficult to determine whether this is occurring.

In Kansas City, Raymond concrete piles were driven through 15 ft. of clean one-man stone, placed over very soft material. The stone was simply displaced and forced into the mud, as evidenced by the fact that, after some of the piles were driven, the surface of the stone in their vicinity had settled some 4 ft.

The engineers on this particular work did not think it possible to drive through the rip-rap, but the steel core was able to secure the results I had mentioned, and perfect piles were secured in the loose rock by leaving the steel shell in place.

My experience with the Raymond Company leads me to conclude that less than half the piles driven carry their load to a definite bearing stratum. In other words, in most cases piles support a load by distributing it more or less uniformly throughout their length to the adjacent soil. It is therefore particularly necessary to consider the bearing power of piles uniformly supported, and experience shows, as I have said before, that the *Engineering News* formula gives the best results for doing this.

FREDERICK A. WALDRON.*—I take pleasure in placing before your Society a few facts relative to the investigation made, and the results obtained in connection with the pile foundations of the new home office building for the John Hancock Mutual Life Insurance Company.

This building is located on Clarendon Street and extends from Stuart to St. James Avenue, and is approximately 250 by 250 ft. It takes the form of a hollow square, with a center tower building of 10 stories in height, surrounded by a building 43 ft. wide, 4 stories high (designed for 10 stories), all having a ground floor and a basement.

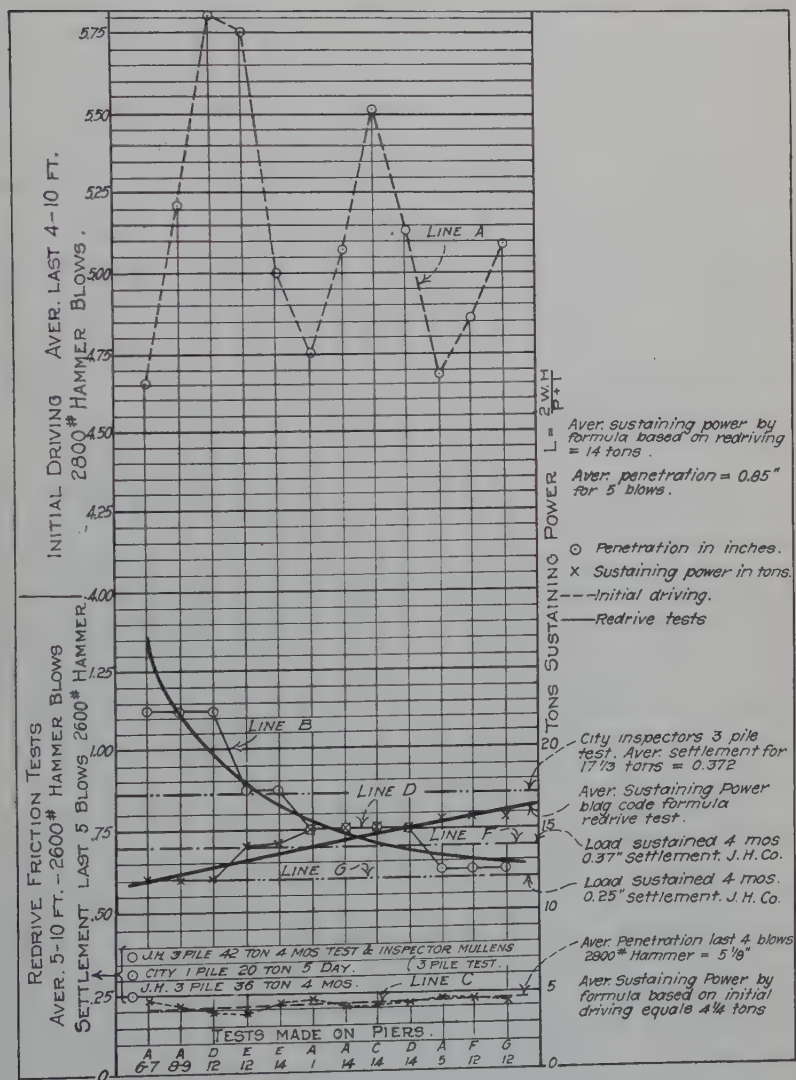
In order to determine the final design of foundations and pile loadings, the following method of procedure was adopted:

A. Borings were made by Guy C. Emerson, C.E., in the early part of 1919, followed later by additional borings made by the John F. Scully Company.

B. The result of these borings showed a bed of hard and medium clay varying in thickness from 17 to 20 ft. The top of this bed was practically level and parallel to the grade of fill, its average depth being about 22 ft. below the grade of the lot.

C. In January, 1919, 2 groups of test piles were driven, containing 3 piles each. The fill around these piles was excavated to the top of the slit and peat. These piles were loaded to 12 and 14 tons respectively, and observations were taken on their settlement for a period of from three to four months. In

* Consulting Engineer, 37 Wall St., New York, N. Y.



PILE PENETRATION, LOADING AND TEST DATA, JOHN HANCOCK MUTUAL LIFE
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order that ice and snow should have no effect on these piles, the pits around them were filled with salt so as to prevent freezing.

The results of the settlement of these tests is shown on the diagram attached herewith. This settlement took place at about seven days after the application of the load, and from that time to the end of the four months' period, readings were taken weekly, and no settlement occurred.

D. It was observed in the driving of these test piles a re-drive test, applied from twenty-four to forty-eight hours after the initial driving, showed a tightening up of the piles and a greatly increased resistance of the soil.

E. It was then decided to assume the load per pile as 12 tons, the maximum allowed by city law, knowing that the type and occupancy of the building would be 30 per cent. less than the maximum.

F. From the results of the test load and the borings, cross sections were developed for different rows of piers, and the length of pile for each pier, predetermined, were driven to these predetermined lengths, regardless of initial penetration.

G. Upon the beginning of actual driving of piles and the city inspection, it was found that the penetration after the fill had been removed entirely from the lot was such that, according to the strict interpretation of the law, a bearing power of less than eight tons was all that the law would allow, based on the average sinking of the pile at its initial driving.

This was so low that the burden of expense that fell upon the owner would be excessive and unreasonable.

H. Tests were therefore started by the city inspector, the results of which are shown on the accompanying diagram.

I. The situation which developed demanded a thorough and drastic investigation of what the subsoil and the piles under the actual conditions would be called upon to sustain, at the final loading of the structure, which resulted in the following method of procedure, the findings of which are plotted on the attached diagram, which is briefly described for convenience and ready reference, as follows:

Re-drive tests were made upon a number of different groups of piles, and their penetration recorded. These groups were

then plotted upon the diagram, beginning with the average maximum re-drive penetration (Line *B*). From records on these groups was plotted the amount of penetration at initial driving (Line *A*).

The sustaining power was calculated by the *Engineering News* formula for both initial (Line *C*) and re-drive penetration (Line *D*), and plotted on the diagram for both cases. The result of the time tests made by the owners and the result of the tests made by the city were then placed on the diagram (Lines *F* and *G*).

It is very interesting to note how closely the formula figures correspond with the sustaining loads allowed by the *Engineering News* formula when applied to the re-drive tests.

On the re-drive tests no increase in penetration was noted after ten blows of a 2 600-lb. hammer falling 8 to 10 ft.

Results. — From this evidence, and at the suggestion of the building commissioner, Wilson, an appeal was made for a load of 10 tons per pile on the building which was to be erected immediately to 10 stories, and 11 tons per pile on that portion of the building which was to be erected to 4 stories for the present and 10 stories later.

In view of the evidence submitted, the above loadings as applied for were fully allowed.

An interesting feature of the diagram shows there is apparently no relation between the sustaining power of a pile in the initial driving and re-driving test.

It also shows that a formula can come very close to the actual conditions if properly applied, and if the unknown quantities of a formula are determined by the engineer with a reasonable degree of certainty, that its results are coincident with the developed facts.

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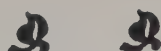
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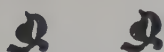
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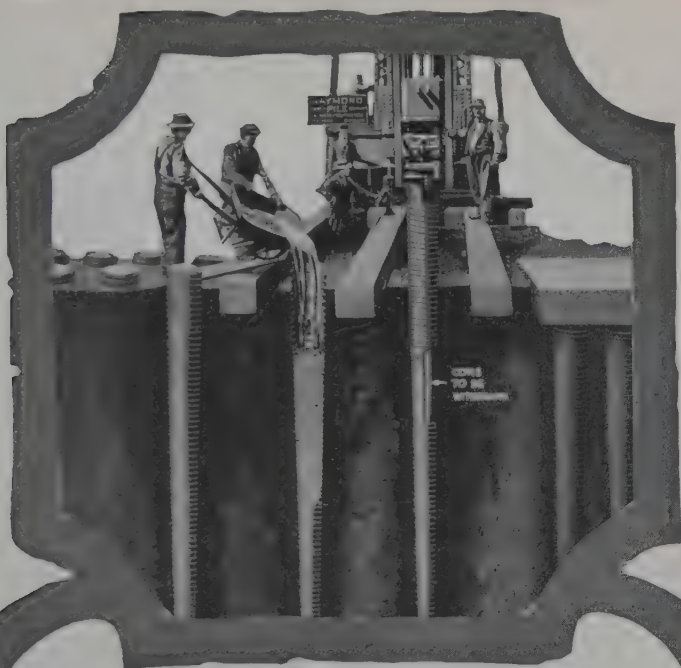
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